Space Weather Technical Forecast

Issued on Friday, 08 December 2023 at 13:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of isolated M-Class flares (R1-R2 Blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is currently Low, peaking at 07/2057 UTC with a C8.2 flare from AR3513, which remains the most active region on the disc with the greatest magnetic complexity. Two moderately large sunspots in the southwest, AR3510 and AR3511, are part of a complex of groups in this area, with magnetic connection between these regions, and AR3511 has produced some lower level C-class flares. AR3507 in the northwest has more of a north-south magnetic alignment, perhaps increasing instability. The other regions on the disc appear mostly smaller and simpler at present, with AR3515 now completely faded.

A number of filament and prominence eruptions have seen CMEs given off that are visible in coronagraph imagery during the past 24 hours. None are currently deemed to any major impacts at Earth, however a filament eruption from the south-centre disc could possibly give an Earth-directed CME, but further imagery and analysis is required to confirm this.

Solar Wind / Geomagnetic Activity: Solar winds as measured by ACE and DSCOVR at L1 show a slow decrease in wind speeds due to the waning effects of CH76/-. Wind speeds briefly rose to elevated levels between 07/1900-1150 UTC, but have been predominantly at slightly elevated levels, currently around 440-450 km/s. Density was initially below average, but increased to average levels from 07/2200 UTC. The Interplanetary Magnetic Field (IMF), Bt, has been weak throughout, staying below 5nT. The north-south component of the IMF, Bz, has varied weakly. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was Quiet (Kp0-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux was predominantly at moderate levels, but very briefly reached High levels, peaking at 1064 pfu at 07/1625 UTC. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu), but with a gradual upward trend. The observation at 08/0000 UTC was 4.056e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate with a chance of isolated M-class flares, mainly from AR3513, but perhaps also from AR3511.

Solar Wind / Geomagnetic Activity: No Earth directed CMEs currently feature in the forecast, beyond a low confidence glancing blow on Day 3 (10 Dec). Solar winds are currently at slightly elevated levels (around 450 km/s) due to waning effects from a coronal hole HSS. Solar winds are expected to continue to gradually decline through the coming days, remaining slightly

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elevated on Day 1 (8 Dec) then reaching background levels during Day 2 (9 Dec). On Day 3, the high speed stream (HSS) from coronal hole CH77/+ is expected to arrive, with speeds increasing to, or close to, elevated levels. The HSS influence likely continuing on Day 4 (11 Dec).

Geomagnetic activity is expected to be largely Quiet (Kp0-2) with a chance of isolated Unsettled intervals (Kp3) until later Day 3, when the arrival of a coronal hole HSS should bring Unsettled to Active (Kp3-4) periods with a slight chance of a G1/Minor Geomagnetic Storm interval (Kp5). Activity is expected to decline to Quiet/Unsettled levels (Kp1-3) later Day 4.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is forecast to remain at background levels, with just a very slight chance of reaching the S1/Minor Storm level should there be any larger flares from the sunspot regions in the western hemisphere.

Electron flux levels are likely to see diurnal maxima above the High level on Days 1-2 (8-9 Dec), until the expected arrival of the HSS from coronal hole CH77/+ likely suppressing the electron belts during Day 3 (10 Dec). Through Day 4 (11 Dec) the electron flux is likely to rise again, possibly reaching High levels at the peak of the diurnal cycle. The associated 24 hour electron fluence is expected to continue to gradually increase on Days 1-2, with a chance to exceed the Active (1e8 integrated pfu) threshold. The fluence is expected to decline through Day 3 but then perhaps showing an upward turn again through Day 4 (11th).

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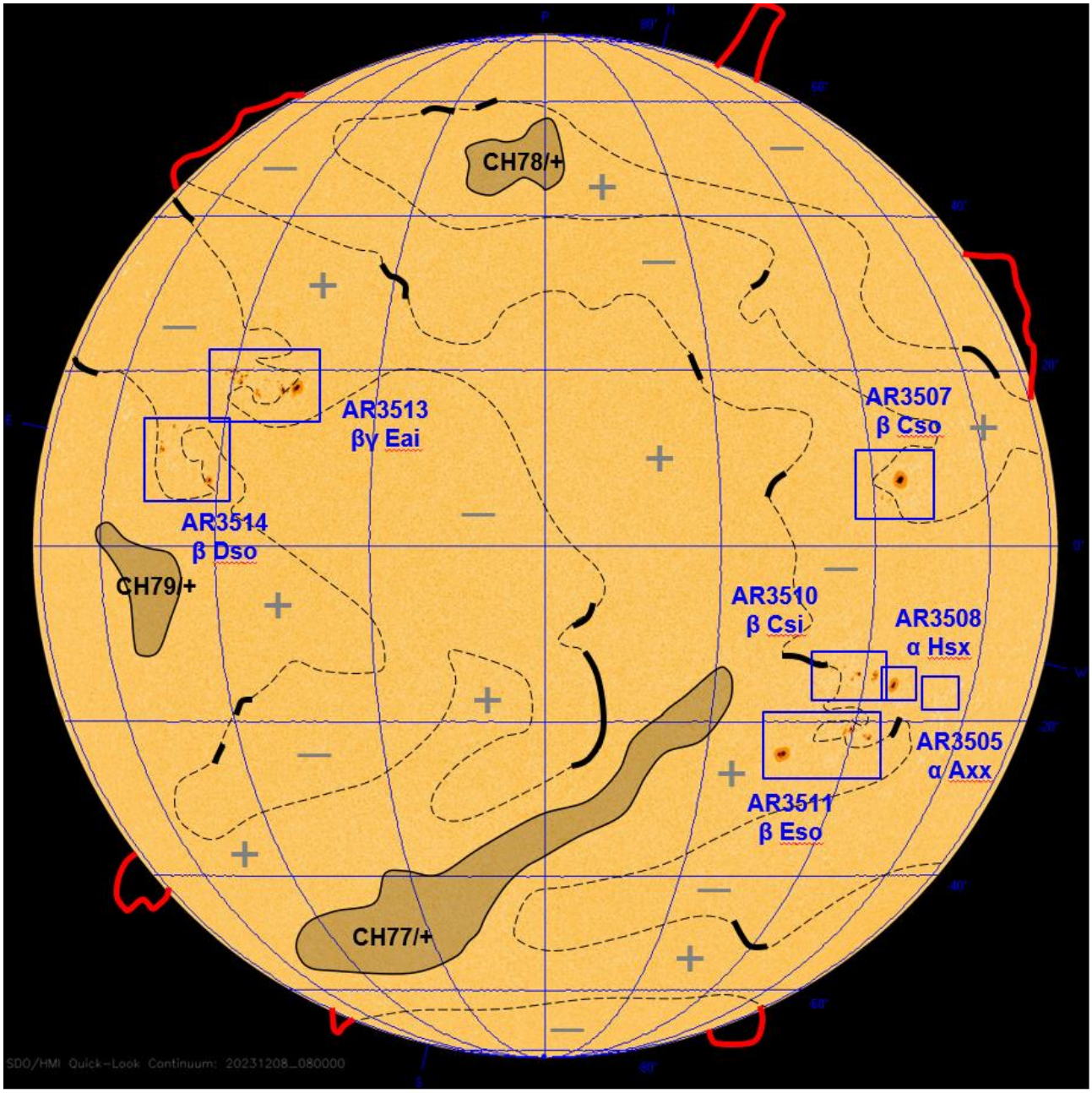
Figure 1. Solar Analysis Valid 08/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There have been various filament eruptions on the Earth-facing disc in the past several days, one of which took place around 07/0200 UTC from the northeast quadrant with a resultant CME emerging to the northeast. MOSWOC Enlil suggests that this could give a weak glancing blow on Day 3 (10 Dec), but this is low confidence. Further CME's have been visible in imagery, most notably on the western and southwestern limb during the 7 Dec UTC evening, due to a large prominence eruption, but currently none are expected to be Earth directed. An asymmetric halo CME was observed at around 07/1330 UTC, but is deemed to be far-sided. A filament eruption located on the south-centre disc occurred at around 08/0520 UTC, with any possible CME given off from this likely to have an Earth-directed component. This is pending coronagraph imagery and analysis to determine.

Solar winds are currently at slightly elevated levels (around 450 km/s) due to waning effects from CH76/-. Solar winds are expected to continue to gradually decline through the coming days, remaining mainly slightly elevated Day 1 (8 Dec) then reaching background levels during Day 2 (9 Dec). On Day 3 (10 Dec), the high speed stream (HSS) from coronal hole CH77/+ is expected to arrive, with speeds increasing to, or close to elevated levels, with the previous rotation suggesting maximum wind speeds of around 550 km/s. The HSS influence likely peaking Day 4 (11 Dec) before beginning to decline.

Geomagnetic activity is expected to be largely Quiet (Kp0-2) with a chance of isolated Unsettled intervals (Kp3), until later Day 3, when the arrival of a coronal hole HSS should bring Unsettled to Active (Kp3-4) periods. There is a slight chance of a G1/Minor Geomagnetic Storm interval (Kp5) also on Day 3 if the glancing blow CME arrives in combination with this HSS. Activity is expected to decline to Quiet/Unsettled levels (Kp1-3) later Day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	5	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
07/1302	Partial	Filament	NE	406 km/s	Late 10 Dec	Low confidence glancing blow

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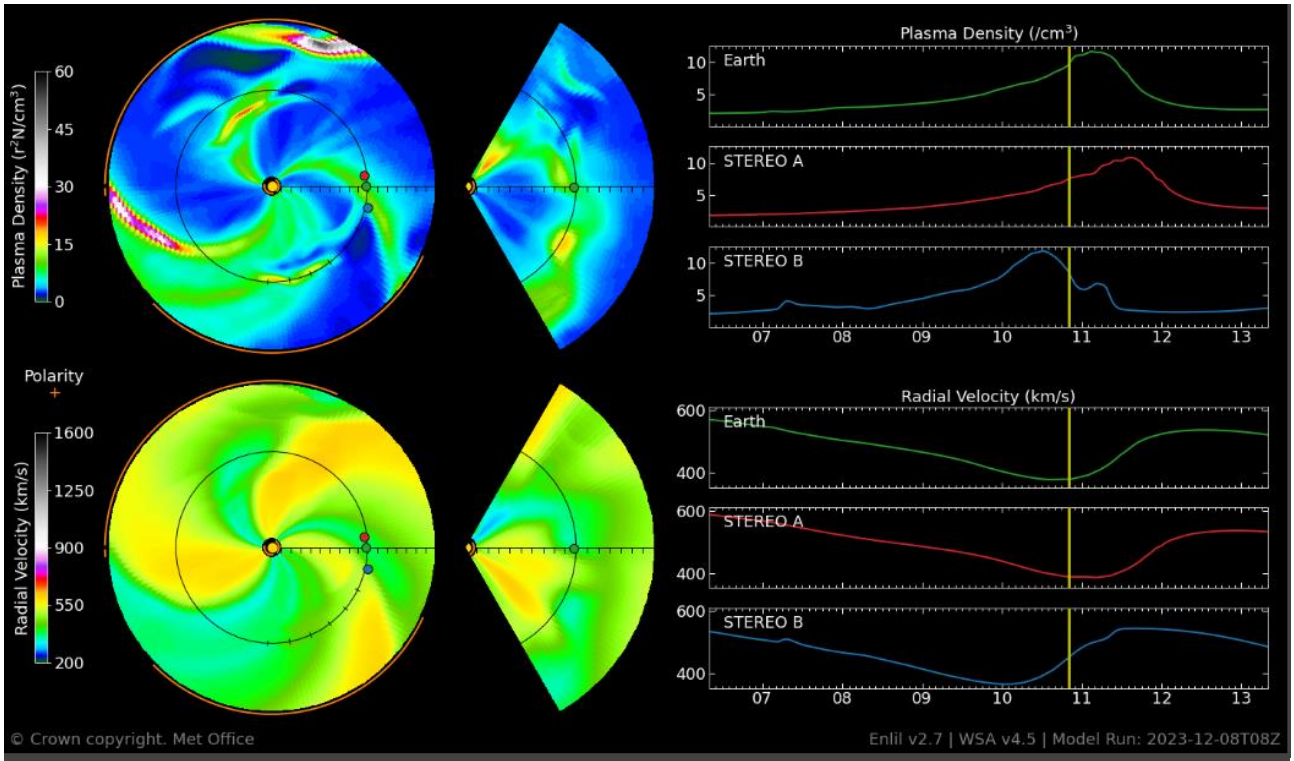
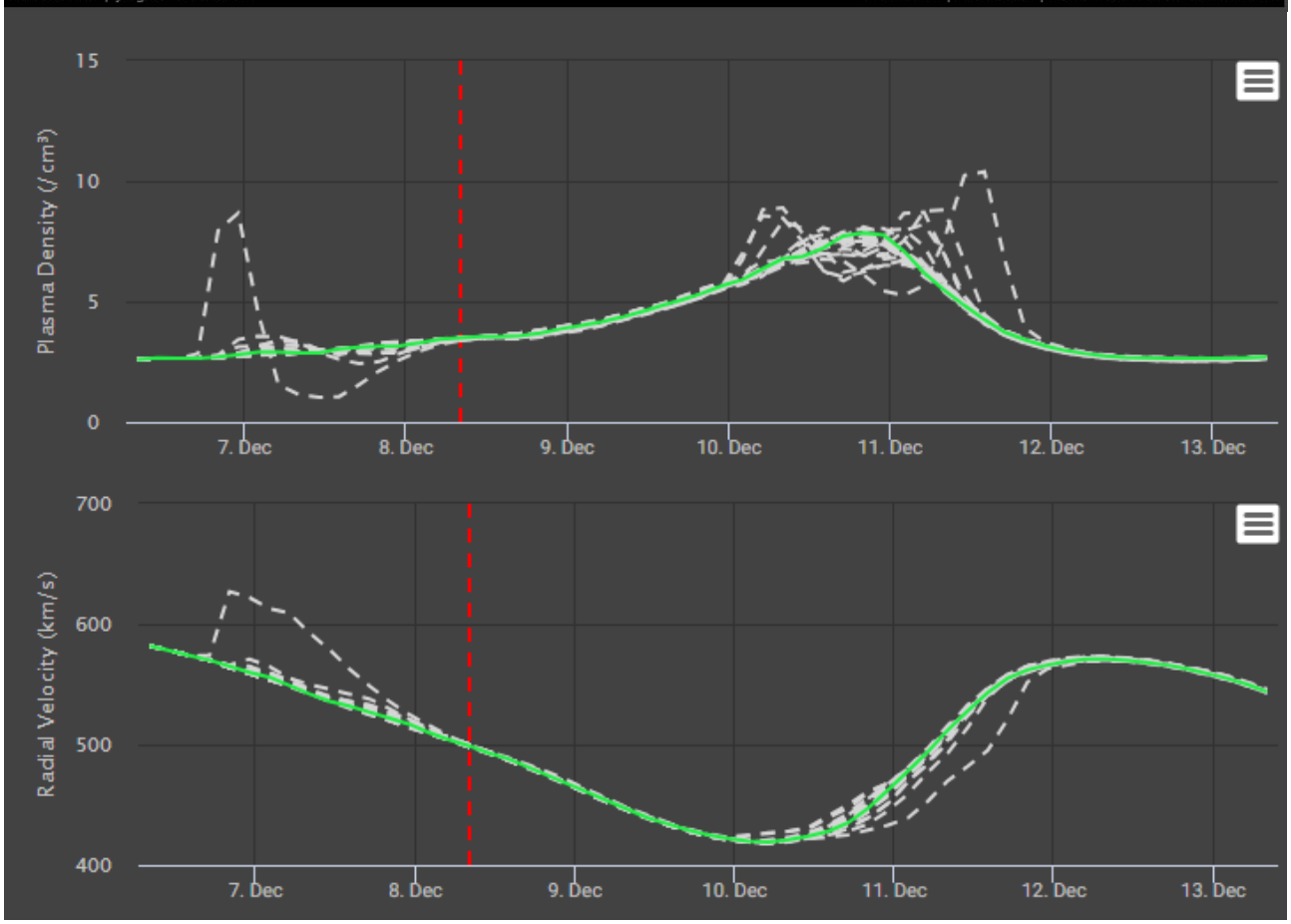
Figure 2: MOSWOC Enlil and ensemble models, showing arrival times of CMEs and CHs





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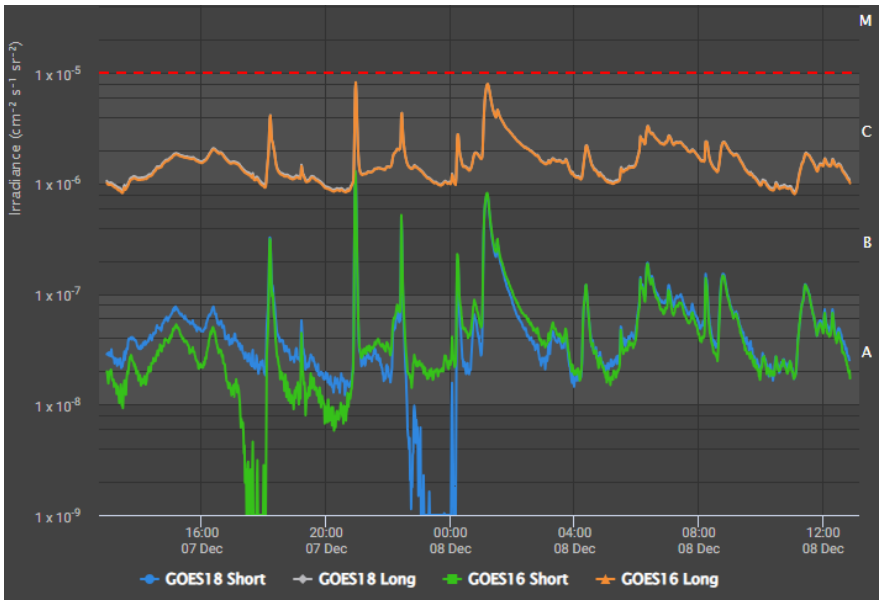
Radio Blackouts - X-Ray Flares:

There are currently six sunspot regions on the visible disc, with AR3505 now faded. The most active region on the disc is AR3513 in the northeast, which has continued to show increased spots number and area. AR3513 is currently classified as Eso/Beta-Gamma, but because of the increase in weak penumbra on the trailing spots a weak Mount Wilson delta spot may be developing. Two moderately large sunspots in the southwest, AR3510 and AR3511, are part of a complex of groups in this area, with magnetic connection between these regions. The spots have continued to gradually spread longitudinally, with AR3410 showing some fading of trailing positive polarity spots. AR3507 in the northwest has more of a north-south magnetic alignment, perhaps increasing instability. The remaining regions on the disc are smaller, magnetically simpler and weaker. A new or returning region is likely to rotate onto the southeast limb during the forecast period, perhaps increasing the probability of significant flares.

Solar activity is currently Low with the largest flare of the past 24 hours a C8.2 at 07/2057 UTC, which originated from AR3513. Low to Moderate activity is expected with a chance of isolated M-flares, mainly from AR3513, but perhaps also from AR3511.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 & 18 X-ray flux



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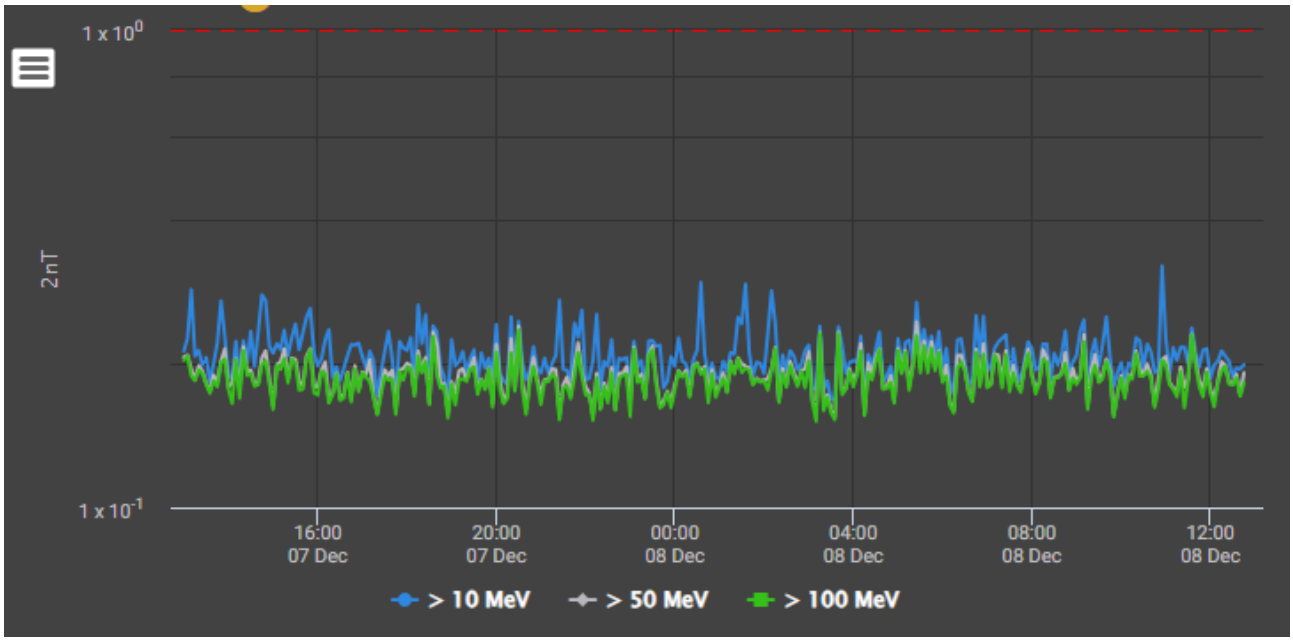
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background levels and is most likely to remain so in the next few days. There is a slight chance of S1/Minor Storm conditions being reached should any significant flares occur, mainly from AR3510 and AR3511 as they rotate further across the western disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 16 Proton flux



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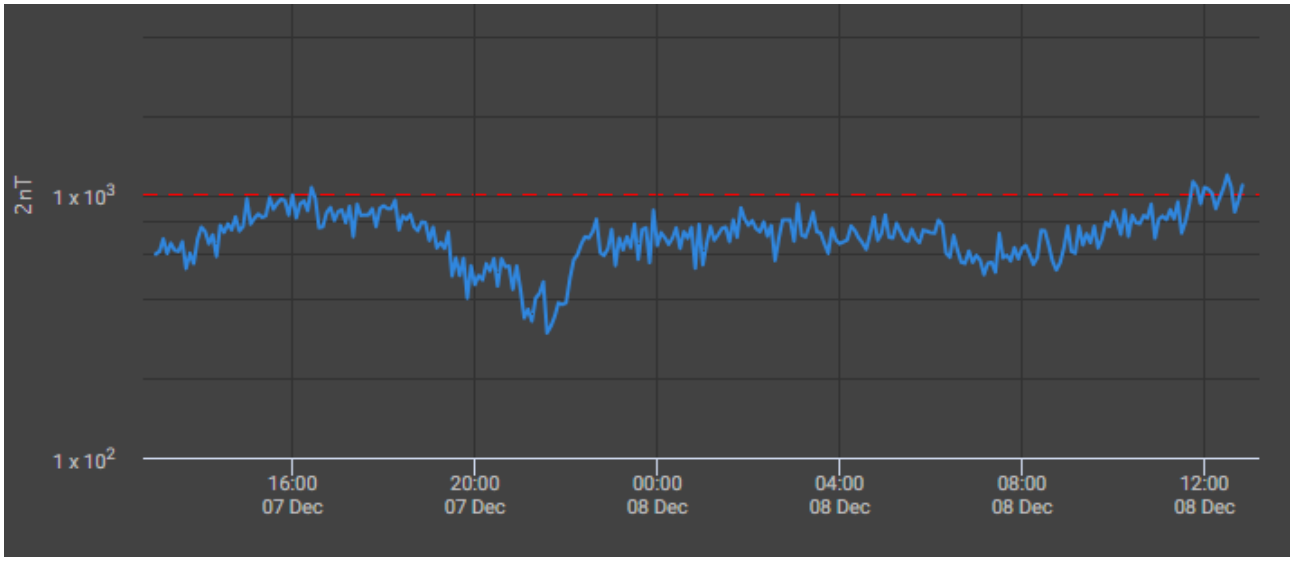
High Energy Electrons Event (≥ 2MeV):
Electron flux is currently at moderate levels. An increase in electron flux, reaching high levels at the diurnal maxima is likely until the expected arrival of the HSS, either late Day 2 (9 Dec) or early Day 3 (10 Dec) from coronal hole 77/+ resulting in a temporary suppression of the electron belts. Through Day 4 (11 Dec) the electron flux is likely to rise again with diurnal peaks possibly reaching High levels.

The associated 24 hour electron fluence is expected to continue to gradually increase through Days 1-2 (8-9 Dec), generally staying below the Active (1e8 integrated pfu) threshold, but with a chance to exceed this threshold. The fluence is expected to slowly decline through Day 3 (10 Dec) as the HSS arrives, but then perhaps showing an upward turn through Day 4 (11 Dec). REFM is considered to be providing reasonable guidance, keeping the fluence below the Active threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	40	50	20	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES16 Electron flux and REFM



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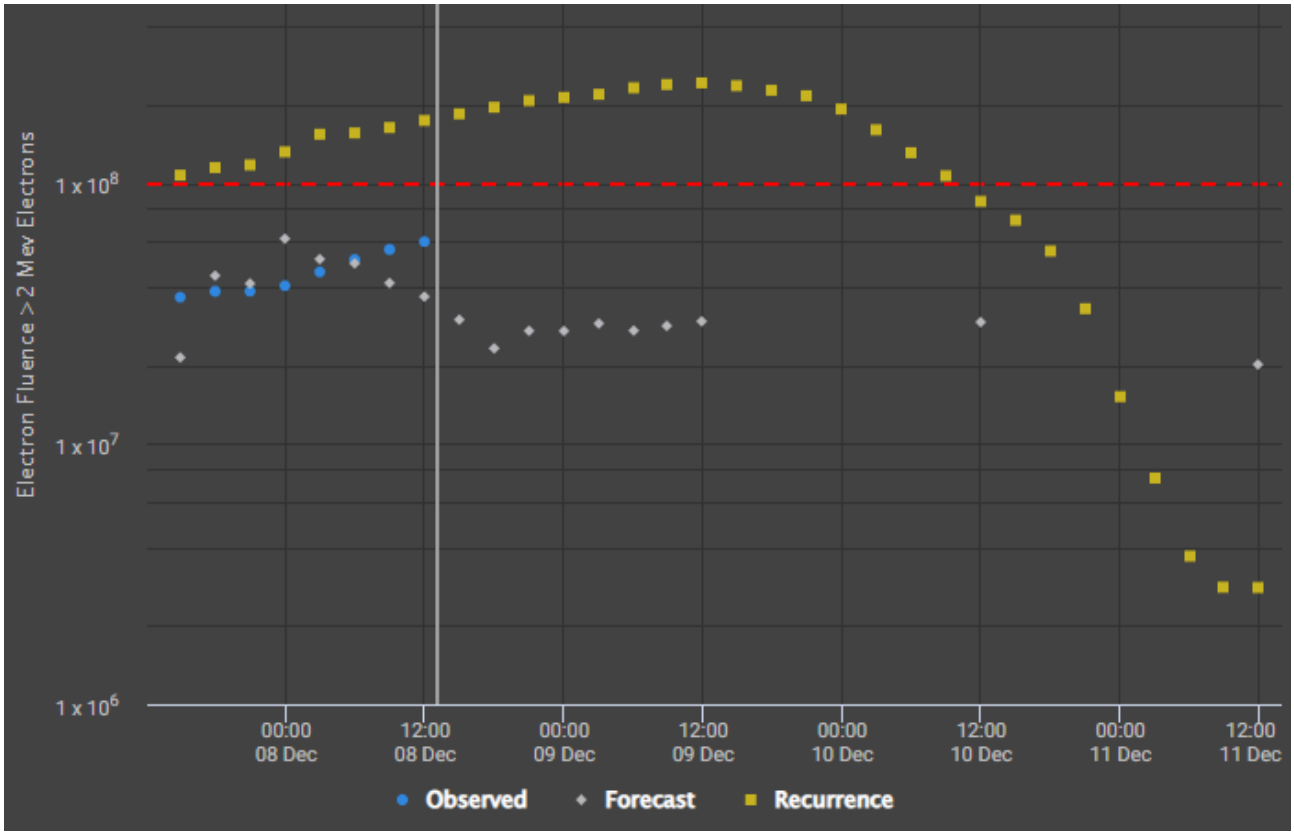

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